STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Aquatic Resources
Honolulu, Hawaii 96813

November 12, 2010

Board of Land and Natural Resources
State of Hawaii
Kahului, Maui

SUBJECT: (1) Report and Assessment of Coral Damage of the Keawakapu Artificial Reef Incident; (2) Evaluation of the Coral Damage; and (3) Issuance of a Fine Against American Marine Corporation for Damage to Coral, Live Rock and the Environment on Unencumbered Submerged Lands in the Conservation District

SUMMARY: 125 of a total of 1400 Z-modules deployed in Keawakapu were dropped totally or partially onto natural coral reef that was situated outside or beyond a 50-yard radius from the marked deployment area surface float. This resulted in 311.79 square meters of coral reef area that were damaged well outside of 50 yards from the marked deployment area. The Keawakapu Artificial Reef project was administered by the Division of Aquatic Resources of the Department of Land and Natural Resources. The Contractor that deployed and dropped the Z-modules was American Marine Corporation.

DATE OF INCIDENT: December 2, 2009

PARTIES: American Marine Corporation
65 N. Nimitz Highway, Pier 14
Honolulu, HI 96817
"Contractor" and "Respondent" or "Responsible Party"

Division of Aquatic Resources
Department of Land and Natural Resources
1151 Punchbowl Street
Honolulu, Hawaii 96813
"Project Manager"

LOCATION OF DAMAGE: Keawakapu Reef, Maui, Hawai`i

JURISDICTION: Hawaii Revised Statutes ("HRS"), Title 12, Chapters 171, 183C, 187A, 188, 189, and HRS 171-6(15), 183C-7, 187A-5, 187A-12.5, 187A-13, 188-53, 188-70 and 189-4

Hawaii Administrative Rules ("HAR"), 13-5 and specifically 13-5-2, 13-5-6, 13-95-2, 13-95-70, 13-5-71

I. INTRODUCTION

Artificial reefs have a long history in Hawai'i, as an effective means to enhance fishery resources and fishing opportunities. In 1957, the Territory of Hawai'i first began considering the possibility of installing artificial shelters in relatively barren areas without natural habitat structures. In 1961, the state installed its first artificial reef at Maunalua Bay in O'ahu. In 1963, two more artificial reefs were installed off Keawakapu, Maui, and Waianae, O'ahu. Additional artificial reefs off Kualoa, O'ahu, and Ewa, O'ahu, were subsequently installed by the state in 1972 and 1986, respectively. The observed benefits of such artificial reef structures include enhanced habitat for coral and other reef species; enhanced biomass compared to the previously "barren" area; and greater biodiversity compared to the previously barren area. http://hawaii.gov/dlnr/dar/artificial_reefs.html

American Marine Corporation ("AMC") is a marine contractor, specializing in commercial diving and vessel support services in Hawai'i, Alaska, and the West Coast of the United States. (http://www.amarinecorp.com/about.htm) AMC has previously been awarded contracts for artificial reef tug and barge services, and has supported the creation of a significant portion of Hawai'i's artificial reef areas.

The artificial reef at Keawakapu, Maui, was first established as an artificial reef site in 1963. Before the date of this incident, artificial reef structures at Keawakapu included 150 cars, 2,250 tire modules, 35 concrete slabs, and one vessel. The artificial reef covers an area of approximately 52 acres, and is located approximately one mile offshore.

On September 2, 2008, the Department of Land & Natural Resources ("DLNR"), with the assistance of the State Procurement Office, awarded contract no. IFB-09-004-O to AMC, for tug and barge services to deploy concrete "Z-modules" at one of six state-owned artificial reef sites. The contract, which was accepted by AMC, specified that the state would mark the deployment areas for each artificial reef (except for the Ewa artificial reef) using surface floats, and that AMC would deploy the Z-module habitats within the area marked by such floats while **"anchored or held at a stable position not more than 50 yards away (within a 100 yard diameter circle) from the marked deployment area."** (See Attachment A, Contractor's Responsibilities 3, Specification Addendum B, IFB-09-004-O).

The AMC barge failed to remain at all times within 50 yards of the surface float placed by Division of Aquatic Resources ("DAR") staff while deploying the artificial reef Z-modules off Keawakapu Reef, Maui. DAR staff, meanwhile, acknowledges that they may not have conducted as thorough a survey of the surrounding ocean bottom as they would have liked to. What is clear and undisputed is that 125 of the 1400 Z-modules deployed in Keawakapu were dropped totally or partially onto natural coral reef that was situated outside or beyond a 50-yard radius from the marked deployment area surface float. 311.79 square meters of coral reef area were damaged well outside of 50 yards from the marked deployment area.

II. Factual Background

A. AMC and Specifications of Contract IFB-09-004-O

On July 14, 2008, with the assistance of, and through the state procurement office, the DLNR posted an invitation for bids for tug and barge services involving the deployment of concrete Z-module "fish habitats." IFB-09-004-O ("IFB") specified that the contractor would need to transport between 400-2000 Z-modules, depending on the carrying capacity of the barge, from Honolulu to one of six designated artificial reef sites. Keawakapu, Maui, was one of these six sites, and if selected, a specified deployment site would be identified through the use of surface floats. Any deployment of the Z-modules would need to occur in water depths of 55-100 feet, and the contractor's barge was to be "anchored or held at a stable position not more than 50 yards away (within a 100 yard diameter circle) from the marked deployment area." (See Attachment A, Contractor's Responsibilities 3, Specifications Addendum B, IFB-09-004-O).

On October 1, 2008, the State of Hawai'i and AMC signed an agreement ("Contract") accepting the terms of the IFB. This Contract included the specifications noted above.

B. DAR's Placement of the Deployment Area Marker

On November 16 and 18, 2009, AMC loaded 1,452 artificial reef modules onto its barge berthed in Honolulu Harbor. In anticipation of the upcoming artificial reef deployment, DAR staff subsequently conducted a pre-assessment dive at Keawakapu Reef, Maui, at a suitable location for expansion of the existing artificial reef. Because of concern for a coral patch reef discovered during the dive, DAR staff decided to shift the deployment location northwest of the original deployment area. A diver was able to verify the suitability of the revised deployment area, and conducted a survey of the surrounding area. However, this survey did not identify the coral reefs beyond the surfaced marked deployment area.

C. Deployment of the Z-Modules in Keawakapu, Maui

On December 2, 2009, the AMC tug-and-barge and two other vessels containing DAR staff traveled to the deployment site. DAR staff verified that the deployment area float had not moved since it had been marked previously. The AMC captain decided to have the tug boat alongside the barge to maintain active control over its lateral movement as opposed to anchoring the barge. The deployment of modules began at about 9:00 a.m. During the deployment, the barge appeared to drift as much as 300 to 400 feet from the deployment area buoy. On at least two occasions, DAR staff requested that the barge be repositioned closer to the deployment buoy.

After all the modules had been deployed, DAR staff conducted a post-deployment dive, where it was discovered that several modules had landed on a coral reef and also an adjacent patch reef at Keawakapu. It was later determined that of the 1,452 deployed modules, 125 had landed on natural coral reef habitat.

Immediately upon discovery of this error, any pending artificial reef deployments were halted by the Department, and a third-party investigation was conducted to assist with and evaluate the damage to the natural resources. In addition, the Department initiated an internal administrative investigation, with the assistance of outside third-party investigators/fact finders, to look into the reasons for and cause of this departmental Artificial Reef project resulting in actual damage to live coral.

Finally, the Department and DAR staff conducted a public meeting on Maui, to discuss their knowledge of the incident, and received public input on how the damage could be mitigated.

III. ASSESSMENT AND VALUATION OF DAMAGE TO THE ENVIRONMENT

A. Coral Damage Assessment by FWS/NMFS

In order to provide an objective third-party analysis of the damage to the environment caused by the module deployment, both the Fish & Wildlife Service and the National Marine Fisheries Service agreed to assist the Department with a preliminary injury assessment. DAR did not participate in this assessment, in order to avoid an allegation of, or appearance of a conflict of interest. The preliminary injury assessment found that 125 of the 1,452 modules landed totally or partially on coral reef, with the remainder landing on sandy areas or beds of *Halimeda spp.* algae. Modules were found in a variety of orientations. The preliminary assessment did not attempt to quantify the economic value of the resources harmed by the impacting Z-modules, due to the complexity of the affected habitats, the variety of module impacts, and the uncertain effects of shaded areas created by the modules. (See Attachment B: Matthew Parry, et. al. Keawakapu Preliminary Injury Assessment (2010) http://hawaii.gov/dlnr/dar/pdf/keawakapu.pdf).

The preliminary assessment identified three options for emergency restoration measures. Notably, a no-action alternative was unlikely to cause further direct injury, due to the depth and size of the modules (which would prevent any further movement from wave action).[1] However, a full or partial removal of all or some of the Z-modules would potentially increase the rate of natural coral recovery, as well as benefit both recreational use and aesthetic value. No specific recommendations were given by the participating federal agency field teams.

B. DAR staff Assessment of Damage to Coral

DAR staff conducted their own assessment of the Keawakapu artificial reef (See Attachment C: Keawakapu Artificial Reef Incident, Coral Damage Assessment) after the federal agencies had completed their independent evaluation and report, in order to get a more detailed understanding of the damage to coral caused by the Z-modules, Taking into account both whole and fragmented modules, as well as accounting for stacked modules, this assessment found 311.79 square meters of damaged reef area.

By surveying surrounding, undamaged reef, DAR staff also estimated the ecosystem value of the damaged coral reef, taking into account characteristics determined to affect coral reef ecological service value.[2] Utilizing standard coral reef assessment techniques and detailed photographic records of the undamaged surrounding reef, DAR biologists were able to measure the rugosity, taxonomy, growth form, percent coral cover, and size structure of the reef. Based on this assessment, the impacted reef was estimated to be composed of 1% high ecological service value corals (lobe and branching corals >80cm), 22% medium ecological service value corals (lobe and branching corals 20cm – 80cm and finger corals >20cm), and 77% low ecological service value corals (all encrusting corals and all other corals <20cm). The reef had a fairly high average rugosity measurement which was consistent with a high value coral reef; however, this high rugosity was attributed mainly to branching finger corals, which offer limited ecological services for most reef fish species. Overall, the DAR assessment found that the impacted coral reef was of medium ecological service value.

[1] The concrete modules that lay atop the corals are stable for now. The modules pose no further threat of additional injury due to the depth of the water. The federal investigation cited above, reached the same conclusion. Unlike ship groundings where the resulting coral (damage) rubble occurred in shallow waters and thus makes live corals susceptible to wave scouring by large summer swells, Keawakapu is located in a site specifically selected to host an artificial reef. It is by definition in a location deep enough where the reef modules are not susceptible to movement, as is evidenced by the fact that the prior modules have been undisturbed for years.

[2] Many of these characteristics were taken into account in previous administrative enforcement cases involving damage to large areas of live stony coral (i.e., the Kai Anela and Kai Kanani cases).

Finally, DAR biologists attempted to determine the number of coral colonies damaged by the Z-modules, using transects across undisturbed nearby reef areas. The average number of coral colonies per transect was calculated at $170/10m^2$; a one-tailed 90% confidence interval was calculated on the total coral numbers, and then independently on each of the three coral ecological value groups (high, medium, and low). This method of estimating the extent of damage to coral, which has been the standard DAR approach in investigating coral damage reports, accounts for natural variability and is conservative in determining the actual number of colonies impacted. Based on the 90% confidence level, and by calculating the number of coral colonies per unit area (m^2), DAR staff estimates the total number of impacted coral specimens at approximately 4,914. The analysis of the individual coral ecological group categories resulted in estimated damage to approximately 31 high value corals, 1,077 medium value corals, and 3,740 low value corals.

C. Recommended Fine as to Coral Damage

The applicable statute, Haw. Rev. Stat. § 187A-12.5(e) (Cum. Supp. 2009), authorizes the Board to assess a fine of "up to $1,000" for each specimen of aquatic life (in this case, coral) taken, killed, or injured in violation of law. The following discussion analyzes fines levied or agreed upon in previous major coral damage matters. The intent is to provide the Board with some guidance and a recommendation as to exercise of the Board's discretion to levy a fine of "up to $1,000" per specimen.

As discussed above, DAR staff conducted their own assessment of the Keawakapu artificial reef. The area and relative ecological value of the damaged coral reef habitat has been estimated within reasonable certainty and generally accepted scientific standards. The Department's analysis and recommendation as to an appropriate fine for the coral damage at Keawakapu is based upon final Board decisions in prior coral damage cases (i.e. Kai Anela and Kai Kanani) and the ecosystem value of the damaged reef habitat.

The Department looked at the prior coral damage cases that were decided by the Board (the Kai Anela and Kai Kanani coral damage cases) and compared both the ecosystem value of the general coral habitat, as well as the amount of impacted or damaged area, in order to determine an area-based evaluation more reflective of the overall ecosystem value for the damaged reef at Keawakapu. Table 1 compares the various options for assessing the damaged Keawakapu reef based on the standards used in these past cases. The Keawakapu case can best be evaluated by comparing it to the fine levied in the Kai Anela case (Table 1, option 2). A direct comparison with the Kai Kanani case (Table 1, option 3) is not reasonable because the damaged habitat in that case was classified as low value flat hard bottom substrate not structured aggregated coral reef such as was damaged with both the Kai Anela and the Keawakapu incidents. An evaluation of the damaged Keawakapu reef based on the fine per unit area in the Kai Anela case results in a per square meter fine of $3,644 and a total amount of $1,136,259 for the damaged 311.79 square meters of reef habitat. This figure obtained with the direct comparison to the Kai Anela case should be considered the maximum potential fine for the damaged reef at Keawakapu. The reef damaged with the Kai Anela case was within the Molokini Marine Life Conservation District (MLCD) and the impacted reef ecosystem was classified as being of high ecosystem value. With the Keawakapu case, however, the damaged reef was not within a highly protected MLCD and was classified as being of medium ecosystem value.

The Department recommends that the square meter fine for the damaged Keawakapu reef should be discounted from the figure outlined above. The Molokini reef damaged in the Kai Anela case was classified as having a high ecosystem value with a large proportion of the damaged corals providing high value ecological services. In contrast, the reef damaged in Keawakapu was composed of only 1% high ecological service value corals, but 77% low value corals. These low value corals were either small (<20cm in size) or encrusting corals providing little habitat for other marine species to utilize. While considering the difference between the two damaged reef ecosystems (Molokini and Keawakapu) staff feel a discount of $500 per square meter would be reasonable. In addition, the Molokini Shoal MLCD is a fully protected marine reserve created in 1977 because of strong community support and an overall desire to protect the unique coral reef ecosystems found within this area. Department staff believe the higher level of management found within an MLCD like Molokini should also result in a higher reef value. In this case, staff suggests that the Keawakapu reef should therefore be further discounted by $500 per square meter to account for the fact that in this case the damage did not occur within an MLCD. These recommended adjustments would result in an estimated Keawakapu damaged reef fine of $2,644 per square meter and a total fine of $824,373 for the 311.79 square meters of damaged reef habitat (Table 1, Option 4). The total fine authorized by statute for the 4914 specimens at issue here is $4,914,000. So the recommended amount, while substantial by any measure, is well within the Board's authority.

Department staff recommends that the Board find the appropriate fine for damage to the 311.79 square meters of coral reef damaged in this case at $824,373. If however, the Board feels a higher number is more appropriate, that final amount should not exceed the number established with the settled value of the Kai Anela case ($1,136,259).

Table 1: Various options for evaluating the reef damage at Keawakapu. Options 1 based on per specimen fine structure used as the maximum in past coral fine cases; option 2 and 3 based on the per unit area evaluation of the reef using the settlement amounts from the damaged area with the Kai Anela and Kai Kanani coral damage cases; and option 4 using the Kai Anela amount and discounting it for the damaged Keawakapu reef.

Options for Assessing an Appropriate Fine for the Damaged Reef at Keawakapu		
Options	**Fine/m2**	**Total Fine**
Maximum Fine ($1,000/coral colony) x (4,914 corals) – HRS 187A	**$1,576.00**	**$4,914,000.00**
Fine based on the per unit area settlement in the Kai Anela case	**$3,644.00**	**$1,136,259.00**
Fine based on the per unit area settlement in the Kai Kanani case	**$140.00**	**$43,706.00**
Proposed fine for the Keawakapu reef based upon discount from the Kai Anela settlement	**$2,644.00**	**$824,372.00**

IV. ISSUANCE OF A FINE AGAINST AMERICAN MARINE CORPORATION FOR DAMAGE TO CORAL, LIVE ROCK AND THE ENVIRONMENT ON UNENCUMBERED SUBMERGED LANDS IN THE CONSERVATION DISTRICT

As noted above, on October 1, 2008, the Department, with the assistance of the State Procurement Office, executed a Contract with American Marine Corporation. Pursuant to the Contract, both parties understood "that this Agreement includes as a part hereof the SPO General Provisions, dated 1/1/2008, the AG General Conditions, dated 6/25/2007; and the Invitation for Bids (IFB) No. IFB-09-004-O including the offer, Special Provisions, and Specifications contained therein."

Under the Specifications of the IFB, Contractor's Responsibilities required AMC to transport and deploy up to 2,000 fish habitat Z-modules to one of the six artificial reef sites constructed by the state. AMC was also required to deploy these habitats "with machinery that would not cause extensive damage to the habitats," in areas where water depth ranged from 55-100 feet "within specific area marked by floats," and while AMC's barge was "anchored or held at a stable position not more than 50 yards away (within a 100 yard diameter circle) from the marked deployment area." The state would be required to "[m]ark deployment areas with surface floats at the selected artificial reef location." (See Attachment A, State Responsibilities 3, Specifications Addendum B, IFB-09-004-0).

While DAR staff did place a deployment marker in the Keawakapu artificial reef area, the AMC barge did not anchor and/or hold itself at all times at a position of equal to or less than 50 yards away from the deployment marker. The barge relied upon a tug boat to maintain its position, and appeared to drift between 300-400 feet (100-133 yards) away from the marker. Although the exact location of the AMC barge while deploying the Z-modules cannot be determined, the nearest Z-module impacting coral reef habitat occurred 62 yards from the marker float, or 12 yards (36 feet) beyond the 50-yard maximum distance where the barge should have been deploying Z-modules. Numerous modules landed well beyond this distance, with the farthest module impacting coral reef occurring nearly 200 yards from the marked deployment area.

The evidence suggests that AMC was negligent and failed to meet its contractual obligations to remain "anchored or held at a stable position not more than 50 yards way . . . from the marked deployment area." In addition, despite being warned by DAR staff about the barge drifting, AMC did not at least attempt to anchor its barge, nor did it appear to stop deploying modules even when it was clearly farther from the maximum 50 yards from the deployment area marker. In the end, 125 modules landed on natural coral reef.

The Department is recommending that the Land Board fine AMC for the damage to coral, more specifically, "**damage to coral, live rock and the environment on unencumbered submerged lands in the conservation district**."

DAR staff does recognize and acknowledge that they may not have conducted as thorough a survey of the surrounding ocean bottom as they would have liked to. Nevertheless, it is clear and undisputed that 125 of the 1400 Z-modules deployed in Keawakapu were dropped totally or partially onto natural coral reef that was situated outside or beyond a 50-yard radius from the marked deployment area surface float. 311.79 square meters of coral reef area were damaged well outside of 50 yards from the marked deployment area. Therefore, the Department approached the principals of AMC to discuss the possibility of entering negotiations in an attempt to arrive at an agreed upon settlement that both parties would be willing to recommend to the Board for its consideration. To the credit of AMC's principals, they agreed to participate, and both the Department and AMC spent a considerable amount of time and energy on the negotiations. The Department presented, for purposes of settlement only and without admitting any fault or liability, the settlement concept of shared responsibility—in that both parties equally share responsibility for the incident, and move forward by working together in restoring the damaged coral at Keawakapu, and finding other restoration or mitigation projects around the State to offset the damage to the environment and lost habitat at Keawakapu. Again, these discussions were for settlement purposes only, with neither party admitting fault or liability. Despite good faith efforts, in the end the parties could not agree upon a settlement amount that both would be willing to recommend to the Board, and therefore, the Department is bringing forth this enforcement action against AMC for the Board's consideration. As noted above, based upon actual prior Land Board decisions in coral damage cases, the Department is recommending that this Land Board find and set the fine for the damage to coral, live rock and the environment on unencumbered submerged lands in the conservation district at $824,373, and fine AMC for the total amount. It is very likely that this matter will end up in a contested case proceeding (should AMC request one), and in such a case, both AMC and the Department will be given an opportunity to bring forth their respective arguments before a Hearings Officer on the issue of responsibility and liability for the incident. The Hearings Officer may find AMC liable for all or a portion of the fine set by the Board. In any event, the recommended findings of fact and recommended decision of the Hearings Officer would ultimately come back to the Land Board for review and the rendering of a final decision. Furthermore, in the event the Hearings Officer finds that the Division of Aquatic Resources should bear some portion of responsibility for the fine set by the Board for the coral damage, then this Board would have an opportunity to direct the Department to identify how it would resolve its portion of the fine and to restore the habitat.

V. Recommendation

The Department recommends that the Board:

1. Adopt and incorporate by this reference the Department's (a) Report and Assessment of Coral Damage of the Keawakapu Artificial Reef Incident; (b) Recommended Fine for the Coral Damage; and (c) Issuance of a Fine Against American Marine Corporation for Damage to Coral, Live Rock and the Environment on Unencumbered Submerged Lands in the Conservation District

2. Fine American Marine Corporation the sum of $824,373.

Respectfully Submitted,

Francis Oishi, Program Manager
Division of Aquatic Resources

APPROVED FOR SUBMITTAL:

Laura H. Thielen, Chairperson
Department of Land and Natural Resources

Attachment(s): A , B, C

ATTACHMENT A

SPECIFICATIONS

SCOPE OF WORK

The Contractor shall furnish all labor, materials, equipment and vessels for the transport and deployment of special designed fish habitats (z-module or prototype) for the Department of Land and Natural Resources (DLNR), Division of Aquatic Resources (DAR), for the twelve-month period commencing October 1, 2008.

Each z-module weighs approximately 2,250 pounds or 1.13 tons. Each z-module is 4 feet wide by 8 feet long with two "legs" on opposing sides that forms an elongated N or sideways Z shape. The z-module is 6 to 8 inches thick.

DAR also uses "deepwater" prototypes. These prototypes are 4 feet wide by 4 feet high by 4 feet deep. The deepwater prototype has a hole through the center, with "walls" of 6 to 8 inches thick. Each deepwater prototype weighs approximately 3,750 pounds or 1.88 tons.

Transport and deployment shall be from Pier 60 or Pier 45 (Snug Harbor) to one of six (6) sites. The designated site shall be determined by the DAR. The maps and coordinated of the six (6) sites are attached.

CONTRACTOR'S RESPONSIBILITIES

1. Contractor shall be responsible for scheduling the use of Pier 60 and loading of fish habitats from apron of Pier 60 onto the barge or vessel. At Pier 45, the Contractor shall be responsible for scheduling the use of the pier through UH Marine Center (847-2661) such that the habitats can be loaded in a timely manner (within 1 or 2 days) by the Contractor during weekdays (Monday through Friday).

2. Contractor shall be responsible for vessel having sufficient draft to enter Pier 60 and while loading fish habitats and exiting Pier 60.

3. Transport and deploy the habitats to one of six (6) sites: 1) Waianae artificial reef located about one mile off Maili Point, Oahu; 2) Maunalua Bay artificial reef, located about one mile offshore of Kahala, Oahu; 3) Kualoa artificial reef, located about one mile offshore of Kaaawa, Oahu; 4) Ewa Deep Water artificial reef, located about 1.5 miles offshore of Ewa Beach, Oahu; 5) the proposed Kalaeloa artificial reef, located about 1.25 miles offshore of Kalaeloa, Oahu; 6) Keawakapu artificial reef, located about one mile offshore of Keawakapu, Maui (maps are attached.) Deploy the habitats with machinery that would not cause extensive damage to the habitats (forklifts are recommended). Deploy the habitats in 55-100 feet of water for site 1,2,3,5 and 6 within specific area marked by floats (see State Responsibilities 3). Deploy the habitats in 300-420 feet of water for site 4 in an area specified DAR, but not marked with floats. Contractor's barge must be anchored or held at a stable position not more than 50 yards away (within a 100 yard diameter circle) from the marked deployment area.

4. Notify DAR two (2) weeks prior to loading of the habitats by calling 587-5404 or 587-0100.

5. Coordinate a transport and deployment schedule which is mutually acceptable to the Contractor and DAR. The mutually acceptable schedule shall be indicated on each purchase order issued against this contract.

6. Deploy the habitats in accordance with the schedule specified on each purchase order issued against this contract. Contractor may be assessed ONE HUNDRED DOLLARS ($100) per day, deducted from the amount due for any delays past the date specified on the purchase order.

STATE RESPONSIBILITIES

1. Have the 400-2000 fish habitats available for deployment depending on the carrying capacity of the barge or vessel available and in accordance with the agreed upon schedule.

2. At Pier 60, oversee the loading and arranging of the habitats onto the barge or vessel by the Contractor. At Pier 45, loading and arranging will be done by the Contractor with approval and supervision from the UH Marine Center personnel and/or DAR.

3. Mark deployment areas with surface floats at the selected artificial reef location, except for the Ewa Deep Water artificial reef where the deployment site will be determined by Global Positioning System (GPS) coordinates.

ATTACHMENT B

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Pacific Islands Fish and Wildlife Office
300 Ala Moana Boulevard, Room 3-122, Box 50088
Honolulu, Hawaii 96850

MAR 19 2010

Ms. Laura Thielen
State of Hawaii
Department of Land and Natural Resources
1151 Punchbowl St., Room 130
Honolulu, HI 96813

Dear Ms. Thielen:

The U.S. Fish and Wildlife Service (Service), National Marine Fisheries Service (NMFS), and Joint Institute for Marine and Atmospheric Research (JIMAR) have prepared a preliminary report on natural resource injury at the Keawakapu Artificial Reef Site on the island of Maui. This preliminary injury assessment was requested by the State of Hawaii, Department of Land and Natural Resources (DLNR) in response to the December 2, 2009, deployment of concrete modules that landed on and damaged coral reef habitat. The report documents and describes the injury areas, the number of modules encountered on reef habitat, and the current position of the modules in relation to the designated artificial reef boundary. The report also provides possible emergency restoration options for consideration by DLNR.

We appreciate the opportunity to work with DLNR on this issue and to provide technical assistance for future assessments if needed. If you have any questions regarding this report, please contact Service Biologist Jeff Phillips by telephone at (808) 792-9454.

Sincerely,

Loyal Mehrhoff
Field Supervisor

Enclosure

Keawakapu Preliminary Injury Assessment

Prepared by

Matthew Parry[1], Robert O'Conner[2], Danielle Jayewardene[3], Nadiera Sukhraj[4], Jeff Phillips[4]

16 March 2010

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[2]U.S. Department of Commerce, National Marine Fisheries Service, Habitat Conservation Division, Honolulu, Hawaii
[3]Joint Institute for Marine and Atmospheric Research, Research Corporation, University of Hawaii, Honolulu, Hawaii
[4]U.S. Department of Interior, Fish and Wildlife Service, Pacific Islands Field Office, Coastal Conservation Program, Honolulu, Hawaii

INTRODUCTION

The Keawakapu Artificial Reef project is located off the south coast of Maui (Figure 1), and was established by the State of Hawai'i Department of Land and Natural Resources (DLNR) in 1962. The artificial reef consists of different structures including 150 cars, 2,250 tire modules, 35 concrete slabs, and one vessel (the "St. Anthony") that have been deployed over time (DLNR, 2009) within a designated zone approximately 54 acres in size. The latest addition to the artificial reef, the first since 1990, was concrete Z-modules deployed in December 2009. These Z-shaped modules weigh about 2,800 lbs (~1.3 ton), and measure eight ft (2.4 m) long by four ft (1.2 m) wide with one foot (0.3 m) long legs projecting in opposite directions at each end. Fifty-two experimental hollow cubes measuring 4 ft (1.3 m) on a side and weighing 4,000 lbs (~1.8 ton) were deployed simultaneously.

On December 2, 2009, an American Marine barge deployed approximately 1,400 modules. The target depth was 60-120 ft (~20-40 m) of water within the official boundary points of the artificial reef zone, as listed in the approved Army Corps of Engineers permit (ACOE, 2005). However, during the deployment a number of modules were accidentally deployed on live coral reef habitat.

DLNR requested assistance from the National Marine Fisheries Service (NMFS) Restoration Center (RC) and Habitat Conservation Division (HCD) and the U.S. Fish and Wildlife Service (FWS) Coastal Conservation Program. DLNR asked NOAA and FWS to conduct a joint natural resource injury preliminary assessment independent from DLNR staff. In order to avoid any potential conflict of interest, DLNR staff were not involved in any phase of conducting this preliminary injury assessment. DLNR and FWS entered into an agreement on December 17 and agreed to a scope of work to be conducted.

NOAA and FWS conducted a preliminary of the natural resource injury using federal injury assessment guidelines found in the Oil Pollution Act of 1990 (OPA) as well as the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The purpose of the pre-assessment was to define areas of injury from the December 2 incident. The preliminary assessment will help guide possible emergency restoration efforts, a more comprehensive natural resource damage assessment, and planning for appropriate restoration of lost habitat.

METHODOLOGY

The pre-assessment had three field objectives:

1) document the total number of deployed concrete modules causing reef injury
2) map the full spatial extent of injury
3) generally describe the injured habitats

Between January 5 and 7, 2010, NOAA and FWS biologists completed a total of fourteen survey dives on the Keawakapu injury site. The modules were mapped using two methods: 1) surface towed Garmin 76s GPS (Global Positioning System) units linked to digital photographs, and 2) an AquaMap™ underwater acoustic mapping system. Resource injuries were documented using digital photography and modules causing reef injury were counted.

Portable GPS units were attached to a surface buoy and towed by each of two dive teams (one team of NOAA staff and one team of FWS staff). Each GPS unit was set to log a continuous track of GPS coordinates every five seconds throughout the dives. Dive teams swam the perimeter of the area. Surface buoys (and GPS) were positioned directly overhead of underwater cameras when photos were taken to reduce errors associated with the angle of the line between the diver and the towed buoy. Using GPS Photo Link™ software the time stamps associated with each digital photo file were linked by time with the synchronized GPS track log coordinate producing geo-referenced photographs. These photographs were then plotted into ArcMap™ software and used to delineate specific areas and habitats.

Higher resolution coordinates of modules were taken using an AquaMap™ underwater acoustic transmitter/receiver system. Four baseline acoustic stations were deployed and a portable handheld transmitter/receiver was used to take relative positional data at the center of each module. A representative photograph was taken of each module for descriptive purposes. The more precise AquaMap™ coordinates were plotted on the larger spatial extent maps to verify coordinates obtained with the surface towed GPS units. The coordinates from this acoustic system resulted in geo-referenced data points with accuracy below 3 ft (~ 1 m). Due to time and technical constraints encountered when deploying the acoustic system at the depth ranges encountered (~ 75 ft/25 m) only one area of injury was mapped to this level of precision. However, all concrete modules causing reef injury were counted and photographed and all areas of injury were mapped with towed GPS-units.

All modules that landed partially or totally on reef were tagged with a unique identifying number laminated in plastic. The numbers were attached to the modules with a cable tie to one of the rebar handles. Four of the modules did not have accessible rebar and identifier tags were attached to adjacent dead coral. A photo was taken of each attached identifier tag. The identifier tags ensured that every module on the reef had been counted and prevented double counting.

RESULTS

Of the reported 1400 modules deployed, 125 were found to have landed partially or totally on coral reef habitat (Figure 2). All modules that landed on coral reef habitat were of the Z-module form; no hollow cube forms landed on reef. The remaining modules landed on sand or sand with beds of *Halimeda sp.* algae. The total area of the module deployment (including modules that landed on the reef) measured approximately 5 acres (~20,000 m^2). The majority of modules did not land on the reef, but dive teams surveyed a larger area to ensure all modules were accounted for. The total area surveyed for injury (estimated from the track logs and spatial maps) was approximately 12 acres (~ 50,000 m^2) (Figure 2). During the survey reef injuries from modules were discovered in two habitat areas, a main reef, and an adjacent patch reef. Surrounding these two habitat areas to the south, west, and north was sand and beds of *Halimeda sp.* algae (Figure 2). These areas are discussed in more detail below.

Modules were observed in a wide variety of orientations in all of the habitats. In general the configurations fell into four basic categories: (1) individual modules lying horizontally flat on the substrate (Fig. 3A), (2) several modules stacked together either partially or wholly overlapping each other (Fig. 3B), (3) modules lying partially or fully on edge (Fig. 3C), (4) fragmented and damaged modules (Fig. 3D).

Main Reef

The main reef in the survey area is part of a reef complex extending to the north and east (Figure 2). The section of main reef surveyed for injury was a ridge approximately 300 ft (~ 100m) wide (north/south) and at least 1500 ft (~ 500 m) long (east/west). The top of the main reef was in approximately 50 ft (~ 17 m) of water with the north side of the ridge sloping to > 100 ft (~ 33 m) and the south edge sloping to approximately 70 ft (~ 23 m). Twenty-five modules were concentrated in a central portion of the main reef on the southern edge of the area surveyed (Figure 2). The condition of the modules in this area varied. Some modules were undamaged and appeared to have impacted the bottom with relatively little physical force (Fig. 4A), but others were damaged, suggesting a greater impact force with the bottom (Fig. 4B, 4C). Most modules in this area of reef were solitary or in pairs, but a few small clusters of modules were observed (Fig. 2D). The density of modules found in this area was low.

An extension of the main reef was impacted by 45 modules with the majority of modules located along the southern edge (Figure 2). This oblong extension of reef was located on the eastern section of the surveyed area of main reef. This portion of reef was attached to the main reef at approximately 50 ft (~17 m) depth, extending southeast and sloping to the sand bottom at 70 ft (~23 m). The density of the modules on this extension was greater than that found on the main section of reef, and modules were frequently observed in overlapping clusters (Fig. 5A, 5B). Some modules were also clustered along the southern margin of the reef protrusion lying partly on sand, and several showed indications of substantial collision force with the substrate (Fig. 5C, 5D).

Patch Reef

Modules were also observed on a patch reef just south of the main reef (Figure 2). The patch reef was approximately 150 ft (~ 50 m) in diameter with the top at 50 ft (~ 17 m) depth and sloping to the sand bottom at 70 ft (~ 23 m). Fifty-five modules were clustered on the patch reef (Fig. 4A, 4B). Modules were observed across most of the patch reef. Many of the modules appeared to have experienced substantial collisions with the substrate and appeared to have slid down the reef slope causing additional damage to coral (Fig. 6C). Some modules lay partially in the sand at the reef/sand margin around the perimeter of the patch reef (Fig. 6D). Most of the hollow cube modules were found isolated and in clustered formation to the east and south of the patch reef.

Total Injury

The primary purpose of this preliminary assessment was to determine the type and extent of the injury. This pre-assessment was not intended to be a full scale natural resource damage assessment. Therefore, comprehensive quantitative data on species composition, ecological function, and coral colony size were not collected. The total injury was difficult to quantify using the information gathered from the preliminary assessment alone. Due to the variety of module configurations observed, some evidence of sliding, and the complexity of the habitat, a simple addition of the area of modules affecting the reef would not accurately quantify the total injury. Not all modules that landed on reef structure caused damage to coral colonies. A few modules were balanced on the colonies underneath, creating a heavily shaded environment. Corals that are currently alive and shaded by the modules will likely undergo a certain level of mortality in any of the emergency response alternatives. The dive teams could not determine if damage was caused by the drifting of modules or the positioning of the barge with the information that was provided.

GENERAL HABITAT AND SPECIES OBSERVATIONS

Coral

Coral cover was high (> 50%), and relatively homogenous across the main and patch reef sections. The coral community was predominantly composed of *Porites compressa*, encrusting and finger-like morphotypes of *Porites lobata*, and encrusting *Montipora capitata* (Fig. 7A, 7B). Colonies of *Montipora patula*, *Pocillipora meandrina*, *Pocillopora damicornis*, and *Pavona varians* were also observed. No larger coral colony mounds were noted and there appeared to be substantial coral fission which made identifying discrete colonies difficult. Broken pieces of *P. compressa* were observed in areas where modules had landed and then shifted and also where module fragments had rolled down slope (Fig. 1D, 5A, 5B, 6C). There was a limited abundance of reef cementing crustose coralline algae.

Macroinvertebrates

Within the area surveyed, divers observed over 100 crown-of-thorns starfish (*Acanthaster planci*). Patches of white skeleton where encrusting *P. lobata* tissue had been eaten were noted in some areas. The urchins *Tripnuestes gratilla*, *Echinothrix calamaris* and *Echinothrix diadema* were present on the modules, the reef substrate and sand, while *Heterocentrotus mammillatus* was only observed on the reef substrate. Herbivory by sea urchins on the cement modules was evident from feeding tracks in the turf algae. The sea cucumber *Holothuria atra* was found throughout the sand patches and the *Halimeda* sp. beds. The day octopus (*Octopus cyanea)* was observed on the patch reef resting on concrete. The state-protected black lipped pearl oyster (*Pinctada margaritifera*) was also present on areas of the reef.

Algae

Non-coral areas of the reef were covered mostly by filamentous turf algae. Macroalgal biomass was low, including a limited amount of crustose coralline algae, a primary cementing organism on coral reefs. *Halimeda* sp. beds were present across much of the sand bottom (Fig. 7C), but were not inspected during this pre-assessment.

Reef Fish

Fish species associated with reef and adjacent sand habitats observed during this pre-assessment are listed in Appendix A. Many of the fish species observed were closely associated with corals having finger and plate morphologies. Fish observations were not made in the *Halimeda* beds and data on these communities should be collected during subsequent field surveys. Large schools of ringtail surgeons (*Acanthurus blochii*), yellowfin goatfish (*Mulloidichthys vanicolensis*), and parrotfish juveniles were observed around the modules, both on the reef and in the sand.

EMERGENCY RESTORATION OPTIONS

Emergency restoration actions should be designed and implemented to prevent any further injury from occurring and remove potential conditions that could impede recovery. Three emergency restoration options are evaluated below based on their: (1) likelihood of causing further injury, (2) monetary cost, (3) effect on natural recovery of the injured resources (and lost ecological function), (4) likelihood of restoring human use, and (5) risk to human health and safety. The likelihood of further injury is considered because coral cover around the modules is high. Monetary cost is considered because the most cost effective option (given the same amount of restoration) should be preferred. The effect of any action on natural recovery is considered because actions that reduce the natural recovery time will reduce the total amount of injury and therefore the amount of compensatory restoration required. Human use is considered because the area is used for ocean recreation and fishing. The following three options represent a reasonable range of alternatives, but they should not exclude other options that could be developed. With any of the options, permitting issues would need to be addressed given that the currently deployed blocks are outside of the Department of the Army permitted area (Permit Number POH-2004-1134).

Option A: No action (leave the modules in place)

Given the depths of the modules (and their size) any further movement of the modules from wave action is unlikely. This no action option is unlikely to cause further direct injury and has the lowest initial cost. However overall costs may be greater over time as recovery of injured coral resources will be slow because coral will not recruit to and overgrow the modules as readily as it would the broken coral matrix beneath them. The State would consequently be responsible for restoration options that take into account the lost ecological resources over a longer recovery window. There may be a level of reduced recreational use of this area which would continue as long as natural recovery was slowed, as well as a loss of natural aesthetic value. There are no risks to human health associated with this option.

Option B: Full Removal

The full removal option entails removing all modules and associated fragments impacting reef regardless of their state and configuration. Modules could be moved by a team of divers using lift bags or barge mounted cranes and redeployed at an appropriate location. If pursuing this option the State should consult with relevant marine salvage companies or other entities that conduct such operations. This option may cause additional injury given that lateral motion of the modules during lifting and towing could create a larger injury footprint. Additional injury during the salvage operation could also result from dropping modules or having to set down a module on the reef during transport. The goal of any removal action would be to lift the modules vertically while minimizing any lateral motion, and then moving them without contacting the reef along the way. This action would most likely have the highest initial cost. Removing the modules would likely increase the rate of natural coral recovery and have a positive effect on recreational use in the area as well as aesthetic value. There would be some risks to human health and safety related to the operators because underwater salvage operations carry a level of inherent risk.

Option C: Partial Removal

This option entails removal of selected modules and associated fragments which could be extracted easily without further coral injury. Modules deemed too risky to move in terms of causing further damage would be left in place. The modules could be moved and redeployed at an appropriate location. This option should cause less injury than the full removal option, but would likely still result in additional injury. If pursuing this option the State should consult with relevant marine salvage companies or other entities that conduct such operations. Additional injury could also occur during the salvage operation. The cost associated with this option should be less than the full removal option. Partial removal of the modules would still result in an increased rate of natural coral recovery in those areas where the modules had been removed; however, those modules left in place would slow recovery of the impacted area. Removing some of the modules from the reef should have a positive effect (although less than full removal) on recreational use in the area and aesthetic value. There would be some risks to human health and safety related to the operators because underwater salvage operations carry a level of inherent risk.

RECOMMENDATIONS

Regardless of which emergency restoration actions are taken, the Federal agencies are available (if requested from DLNR) to assist with a thorough injury assessment that would more precisely quantify the injury related to the module deployment. This type of information would assist with designing future restoration projects so that the amount and type of restoration is equivalent to the amount and type of resources injured or lost. The additional information collected in a full assessment would also enable a more accurate projection of the recovery time of the injured resources. If complete or partial module removal is the selected emergency restoration action, the Federal entities could be available (if requested from DLNR) to provide on-site technical assistance during operations, quantify any additional injury associated with the activities, and re-estimate the time for natural recovery post-action.

For additional actions, NOAA and FWS recommend DLNR conduct restoration for the resource injury that occurred from the deployment of the modules including the interim loss until the projected reef recovery. Restoration plans should be developed in consultation with the resource agencies and the affected public.

Disclaimer

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References

DLNR. 2009. State to expand Maui's Keawakapu Artificial Reef on Monday. NR-313, November 25, 2009.

ACOE. 2009. POH-2004-1134. Permit for maintenance and expansion of existing artificial reefs under jurisdiction of the State of Hawaii. U.S. Army Engineer District, Honolulu.

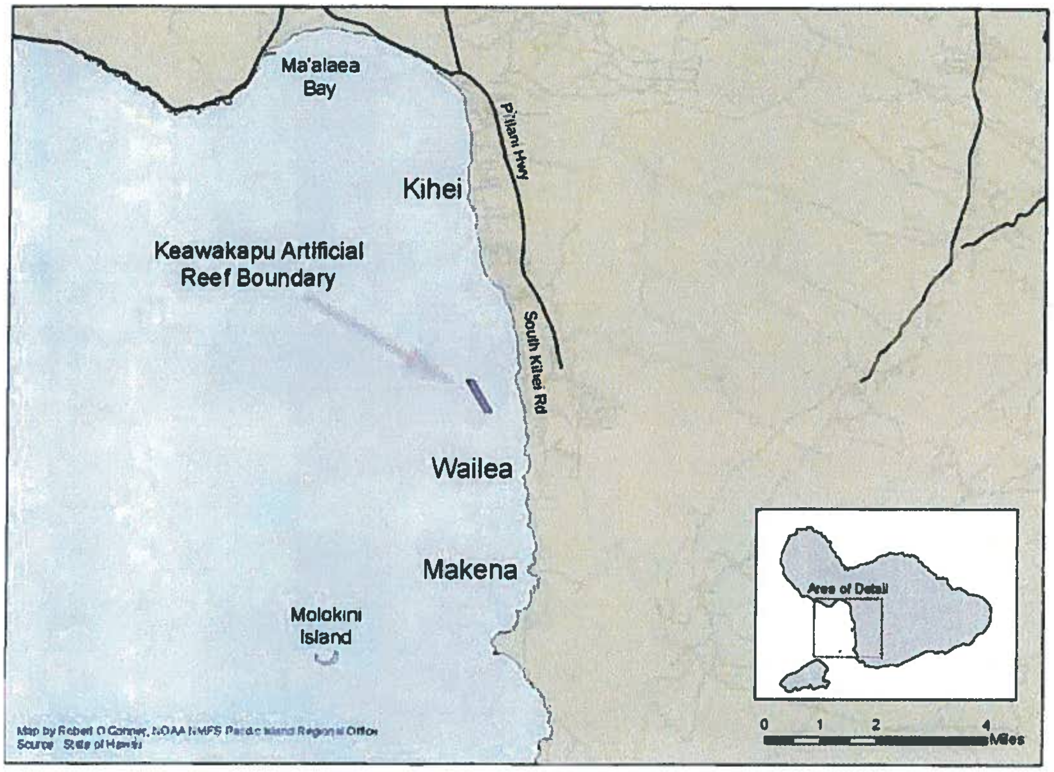


Figure 1. Overview of the Kihei coast on Maui showing the relative position of the Keawakapu Artificial Reef designated area. This polygon was generated using coordinates obtained from the DAR artificial reef website.

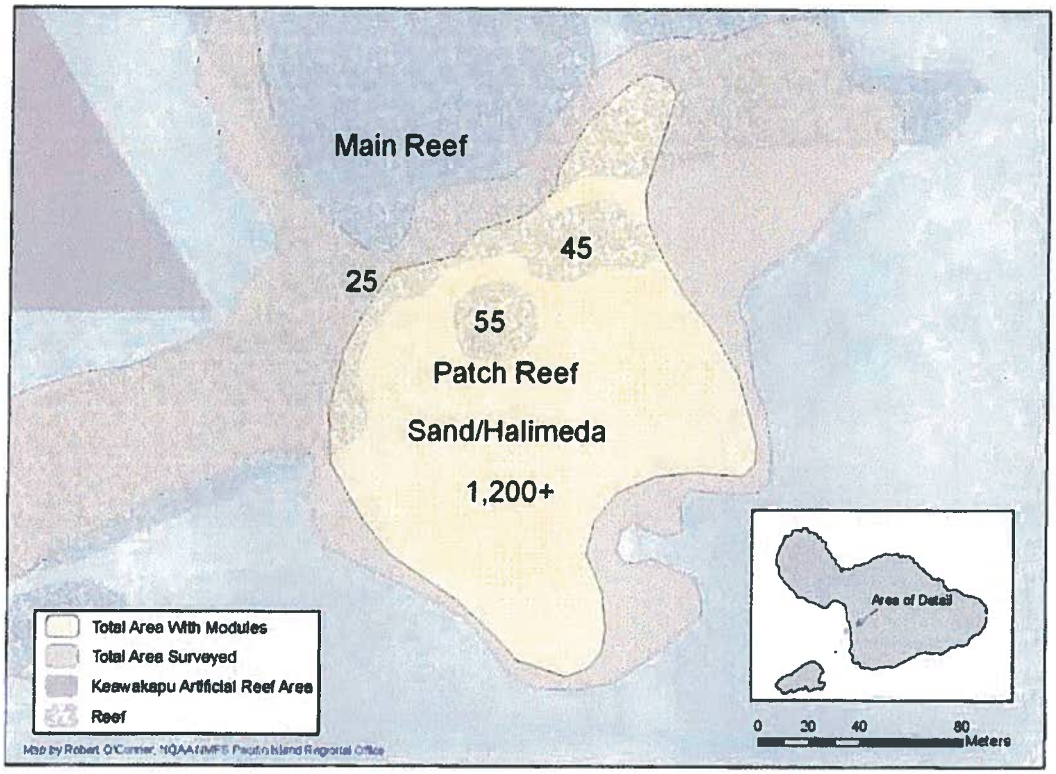


Figure 2. A detail map showing the area surveyed during the three-day pre-assessment project and the spatial extent of the module deployment. The numbers denote the number of modules found on the main reef (25), the extension from the main reef (45), and the patch reef (55). The remainder of the modules (1,200+) was found on sand or sand with *Halimeda sp.* habitat. The southeast corner of the designated Keawakapu Artificial Reef area can be seen on the top left of the map.

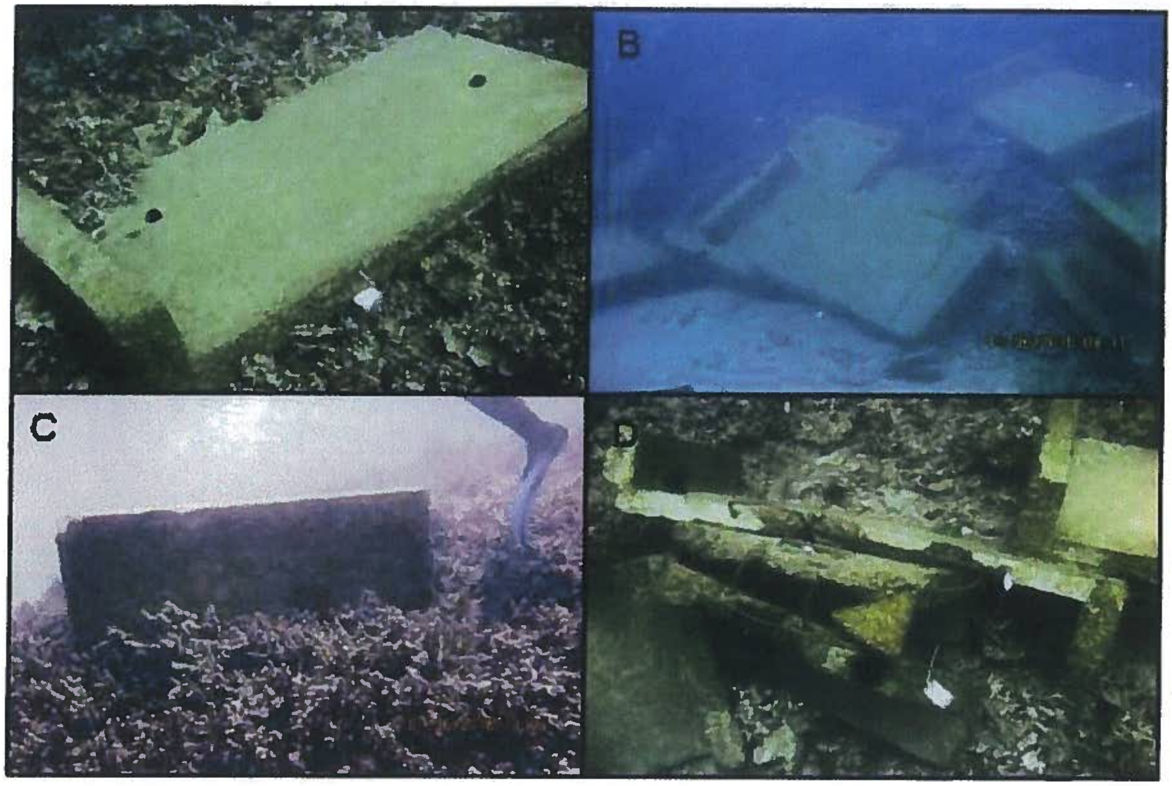


Figure 3. Four representative module orientations found on the reef.

A) An individual solitary module lying flat along one face.

B) A cluster of modules overlapping each other with some modules lying partially in sand.

C) An individual module lying upright along its long axis.

D) A cluster of modules showing signs of substantial collision with the reef (modules are fragmented and broken). A perimeter of broken coral can be seen surrounding the cluster indicating that the modules slid after impact.

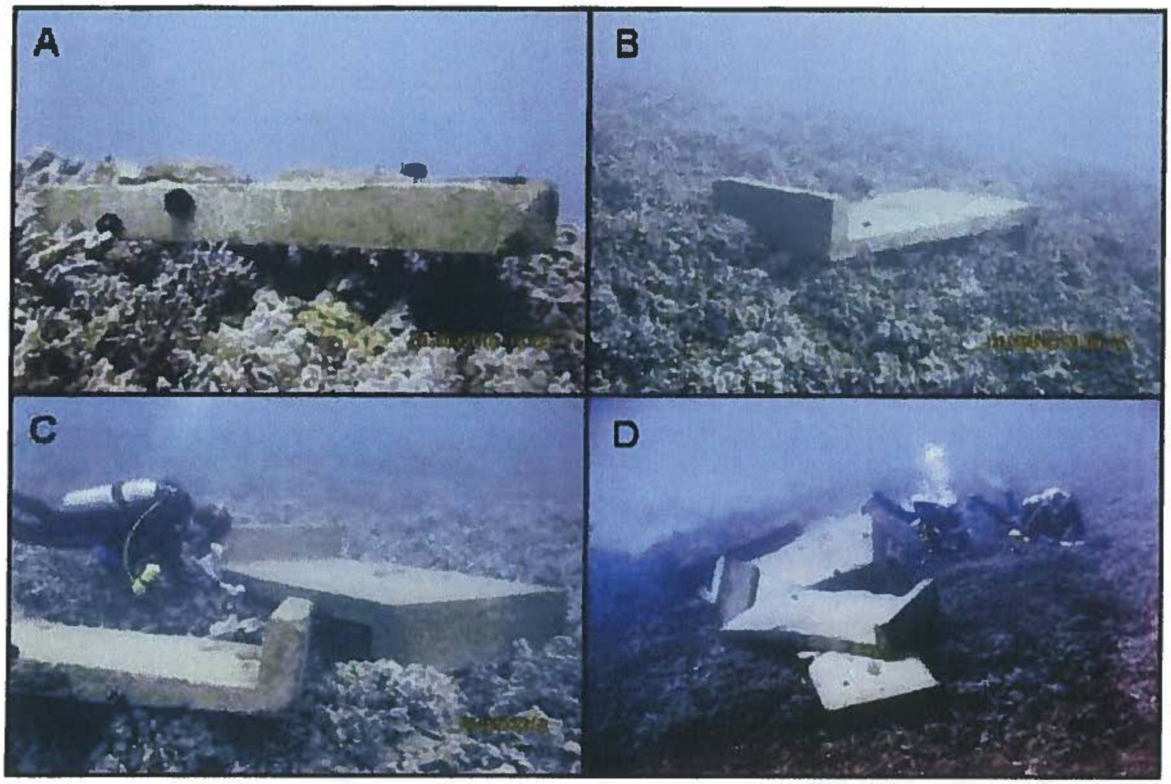


Figure 4. Modules found on the main reef area.

A) An individual module that appears to have settled on the reef without breaking all the coral underneath it. Intact coral can clearly be seen underneath the module, supporting its weight. Shading under the module is evident in the photo and will likely result in some coral mortality.

B) A solitary individual module showing a crack across the top indicating that it may have settled with substantial force.

C) A pair of modules on the main reef that was representative of the typical density of the modules in this area. Note intact coral can be seen under the module in the foreground.

D) A cluster of cracked and broken modules that was atypical of the density of modules in the main reef area.

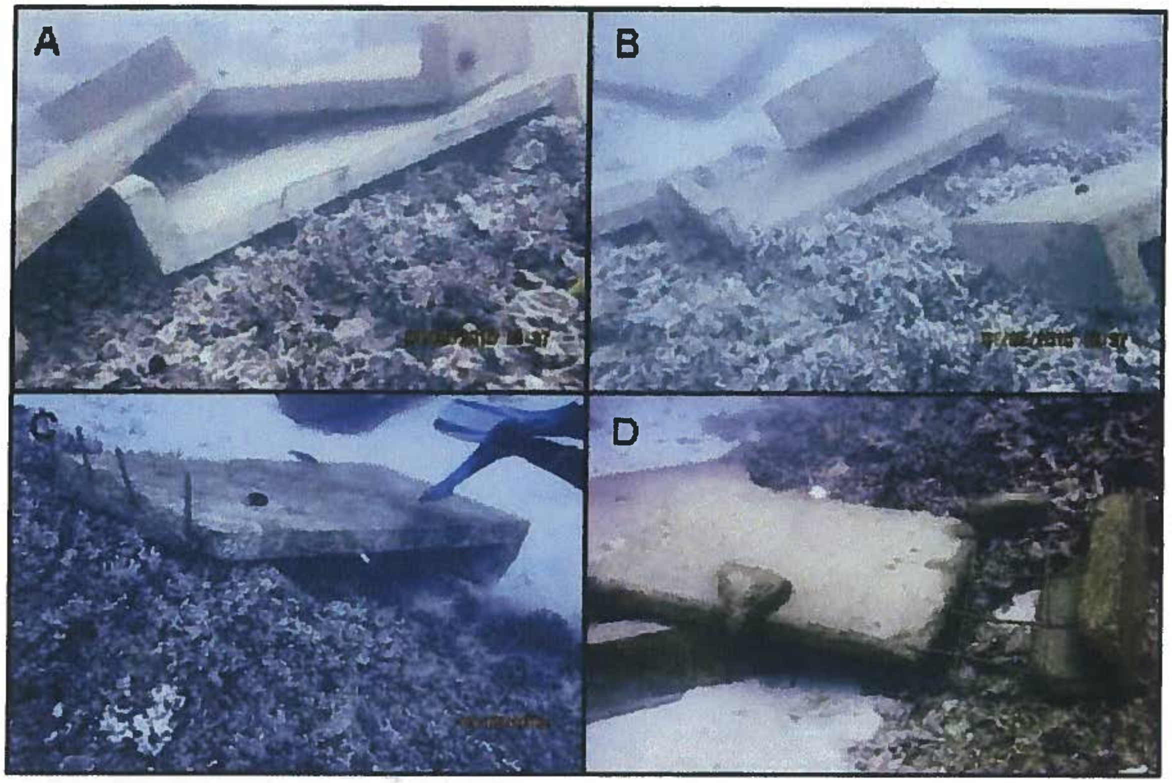


Figure 5. Modules found on the extension of the main reef.

A) An overlapping cluster of modules on the extension of the main reef. Broken coral can be seen in a perimeter around the modules indicating that they slid down slope causing additional injury to coral.

B) A typical overlapping cluster of modules on the reef perimeter showing evidence of sliding.

C) A module lying partially on reef and partially in sand. The edge of the module has been broken off exposing the internal rebar structure.

D) Overlapping modules lying partially in sand. The top module has been broken exposing the internal rebar framework. Module fragments can be seen nearby.

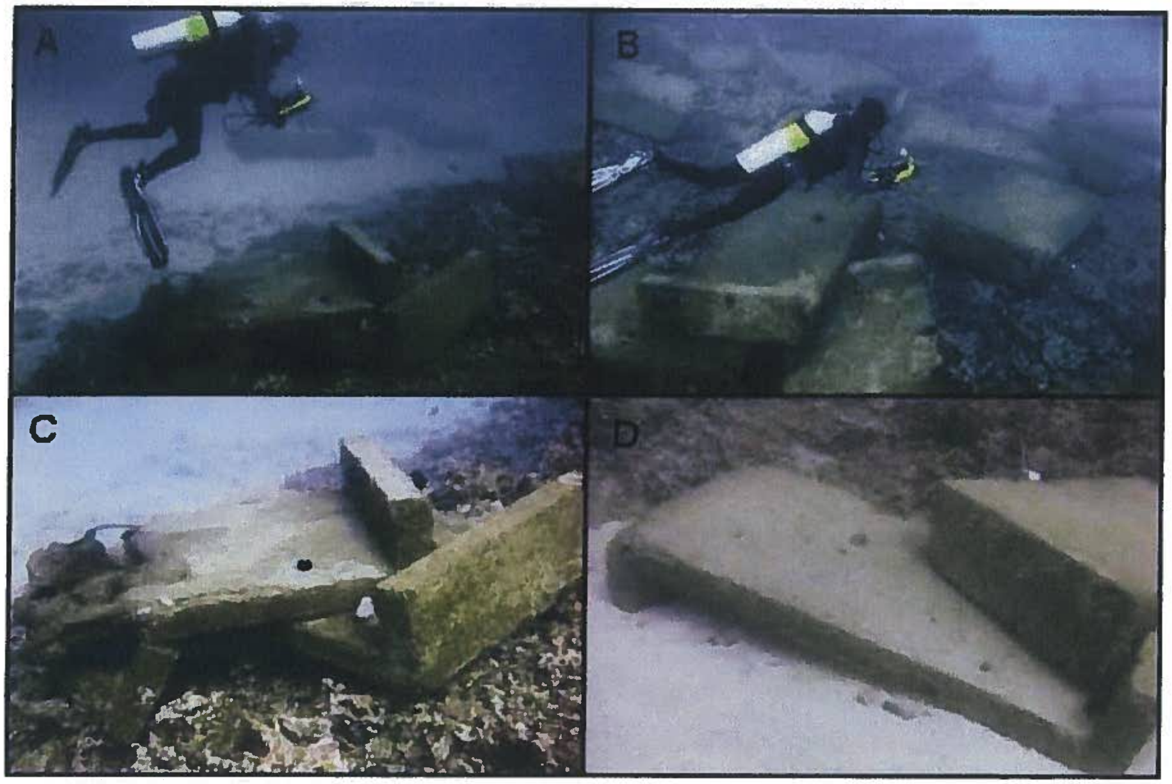


Figure 6. Modules found on the patch reef.

A) Overlapping modules on coral.

B) A representative photo showing the density of modules on the patch reef. Of all the reef areas surveyed, the density of modules was highest on the patch reef.

C) An overlapping cluster of modules showing signs of substantial collision with the reef. The modules are broken and a perimeter of injured coral can be seen surrounding the modules indicating that they slid down slope.

D) An overlapping cluster of modules along the reef/sand margin of the patch reef. The modules are lying partially in sand and partially on reef.

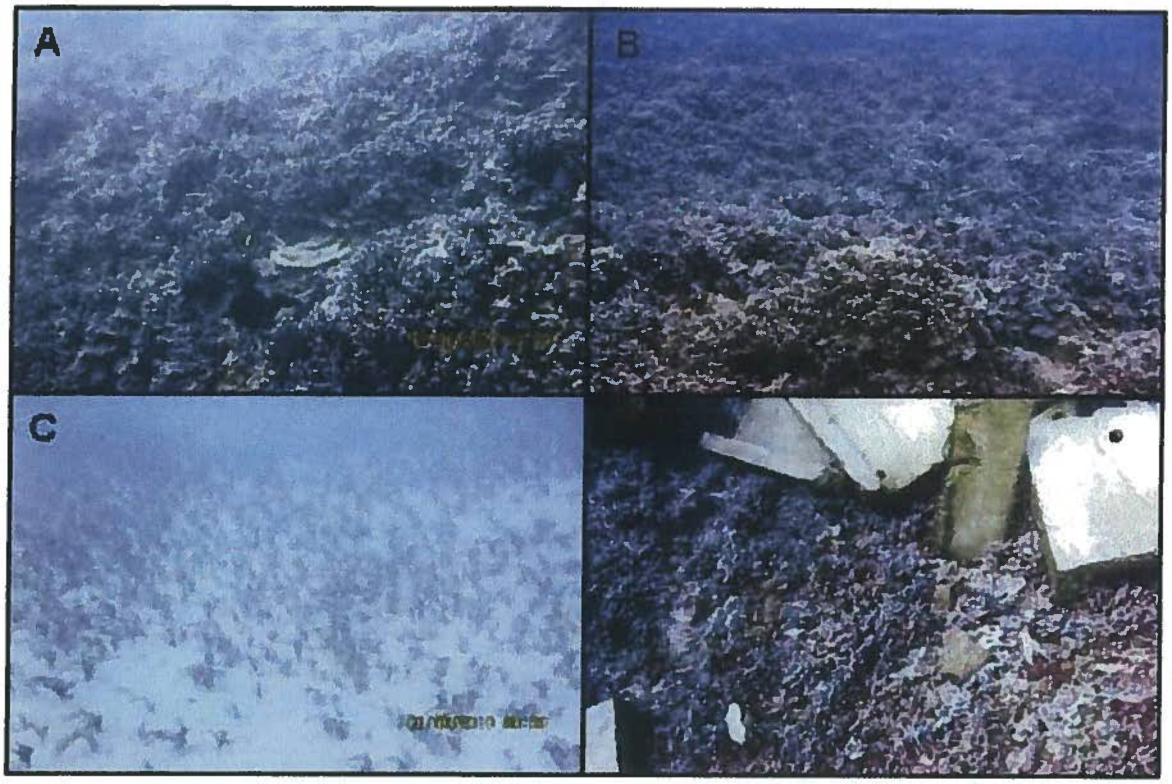


Figure 7. Representative photographs of the habitats and species in the area.

A) The reef showing several species and relative coral cover typical of all surveyed areas.

B) The reef showing several species and relative coral cover typical of all surveyed areas.

C) Sand bottom habitat with *Halimeda* sp. beds. This habitat surrounded the reef areas and contained the majority of deployed modules.

D) Fragments of broken *Porities compressa* coral seen commonly in most injured areas.

Appendix A

Keawakapu Artificial Reef: Reef fish species observed Wednesday, January 6, 2010 on reef habitat and adjacent sand

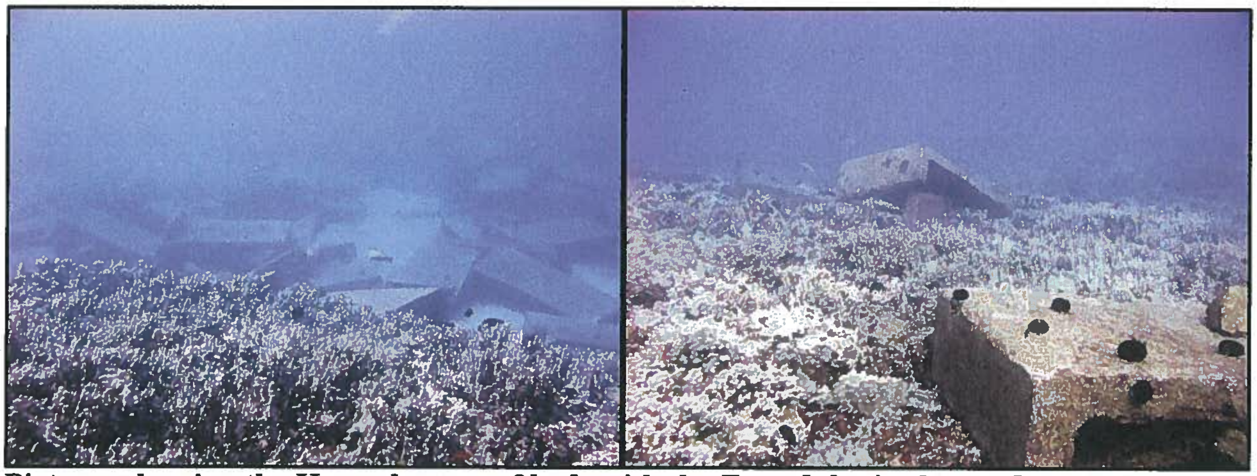
Family	Scientific Name	Common Name
Chaetodontidae	*Chaetodon unimaculatus*	teardrop butterflyfish
	Chaetodon multicinctus	multiband butterflyfish
	Chaetodon auriga	threadfin butterflyfish
	Chaetodon lunula	raccoon butterflyfish
	Forcipiger flavissimus	longnose butterflyfish
	Hemitaurichthys polylepis	pyramid butterflyfish
Acanthuridae	*Zebrasoma flavescens*	yellow tang
	Ctenochaetus strigosus	gold ring surgeonfish
	Zebrasoma veliferum	sailfin tang
	Acanthurus nigroris	blueline surgeonfish
	Acanthurus blochii	ringtail surgeon
	Naso lituratus	orangespine unicornfish
	Naso unicornis	bluespine unicornfish
	Naso hexacanthus	hornless unicornfish
Pomacentridae	*Dascyllus albisella*	Hawaiian domino
	Chromis hanui	chocolate dip chromis
	Chromis vanderbilti	blackspot chromis
	Chromis verater	threespot chromis
	Plectroglyphidodon johnstonianus	blue eye damsel
Scaridae	*Chlorurus sordidus*	bullethead parrotfish
	Scarus psittacus	palenose parrotfish
	Scarus perspicillatus	spectacled parrotfish
Labridae	*Bodianus bilunulatus*	Hawaiian hogfish
	Coris gaimard	yellowtail coris
	Coris flavovittata	yellowstrip coris
	Pseudocheilinus octotaenia	eightline wrasse
	Stethojulis belteata	belted wrasse
	Thalassoma duperrey	saddle wrasse
	Cheilinus unifasciatus	ringtail wrasse
Balistidae	*Melichthys vidua*	pinktail triggerfish
Monocanthidae	*Cantherhines dumerilii*	barred filefish
Serranidae	*Cephalopholis argus*	peacock grouper, roi
Cirrhitidae	*Paracirrhites arcatus*	arc eye hawkfish
	Paracirrhites forsteri	blackside hawkfish
Lutjanidae	*Lutjanus fulvus*	blacktail snapper
	Monotaxis grandoculis	bigeye emperor
Mullidae	*Mulloidichthys vanicolensis*	yellowfin goatfish

Family	Scientific Name	Common Name
Tetraodontidae	*Canthigaster coronata*	crowned toby
	Canthigaster epilampra	lantern toby
	Canthigaster jactator	Hawaiian spotted toby
Diodontidae	*Diodon hystrix*	porcupinefish
Holocentridae	*Myripristis kuntee*	pearly soldierfish
Aulostomidae	*Aulostomus chinensis*	trumpetfish
Fistularidae	*Fistularia commersonii*	cornetfish
Pomacanthidae	*Centropyge potteri*	Potter's angelfish
Sphyraenidae	*Sphyraena barracuda*	great barracuda
Priacanthidae	*Priacanthus meeki*	Hawaiian bigeye
Blennidae	*Cirripectes vanderbilti*	scarface blenny
Pinguipedidae	*Parapercis schauinslandi*	redspotted sandperch
Synodontidae	*Saurida flamma*	orangemouth lizardfish
Microdesmidae	*Ptereleotris heteroptera*	indigo dartfish
Muraenidae	*Gymnothorax undulatus*	undulated moray
	Gymnothorax meleagris	whitemouth moray
Myliobatidae	*Aetobatus narinari*	spotted eagle ray
Carcharhinidae	*Triaenodon obesus*	whitetip reef shark

ATTACHMENT C

Keawakapu Artificial Reef Incident
Coral Reef Damage Assessment

August 5, 2010



Pictures showing the Keawakapu reef beds with the Z-modules in the sand near the reef's edge, and some of the Z-modules sitting on the coral beds where they were accidently deployed.

<u>Field Assessment Conducted By</u>
Russell Sparks
Paul Murakawa
Brett Schumacher
Kristy Stone

<u>Assessment Report Compiled By</u>
Russell Sparks
Paul Murakawa

Overview

The Keawakapu Artificial Reef (KAR) was established as a state artificial reef area by the Department of Land and Natural Resources (DLNR) in 1962. The artificial reef zone begins at the St. Anthony vessel in the southeast and continues along a northwest heading for a total designated area of roughly 54 acres. Past GIS mapping efforts had mistakenly placed the KAR further offshore and away from the existing material. By correctly converting old marine coordinates, this mistake has been corrected with the resulting KAR boundaries shown in Figure 1. Artificial reef deployments within the KAR began in 1962 when 150 car bodies were deployed on the site. Deployments continued in 1979 with the addition of 80 tire bundles, in 1989 with 1,000 tire modules, in 1990 with 1,170 tire modules and 35 Z-modules, and in 1997 with the sinking of the *St. Anthony* vessel. In December 2009 the DLNR conducted a deployment of 1,400 concrete Z-modules and 52 experimental hollow cubes. Unfortunately 125 of the Z-modules were deployed outside of the intended drop zone and landed on undisturbed natural coral reefs. This report will detail the results of a damage assessment conducted in July 2010 by the DLNR, Division of Aquatic Resources (DAR). This assessment included detailed measurements of all directly damaged coral reef areas, and a thorough investigation and classification of the surrounding undisturbed coral reef habitats. This DAR site inspection followed established reef damage assessment protocols utilized by DAR on past Hawaii coral damage investigations.

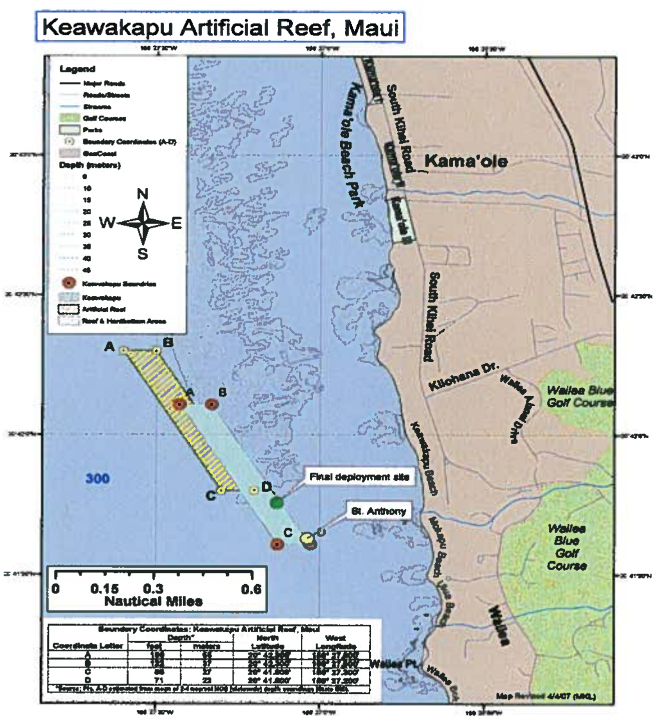


Figure 1: Map of the Keawakapu Artificial Reef Area. The old incorrectly mapped zone is shown in diagonal yellow lines, and the new appropriately mapped zone is shown in solid light green. The December 2009 drop site is shown as the green circle, and the vessel *St. Anthony* is shown for reference with the yellow circle.

Assessment Methods

Total Damaged Area Assessment

In early January 2010, biologists from the National Marine Fisheries Service and the United States Fish and Wildlife Service conducted a preliminary injury assessment of the coral reefs impacted by the December 2009 deployment ("Keawakapu Preliminary Injury Assessment, March 16, 2010"). This independent federal assessment identified, tagged, and documented 125 (4' X 8') concrete modules on the reef. Subsequently biologists from the DLNR, DAR conducted more detailed mapping and photo documentation of the impacted area. However, neither of these initial assessment efforts fully quantified the total area of reef that was damaged by the December 2009 deployment incident. The first step of this assessment, therefore, was to thoroughly measure and document all of the reef damage that occurred at the 125 previously identified Z-modules. Detailed measurements were required because some modules are only partially on the reef, some are sitting sideways or at an angle, some are stacked on other modules, and there may also have been some other impact damage that was not apparent on photographic evidence (for example, damage from modules sliding down the reef, or from broken pieces of concrete falling on other portions of the reef habitat).

The damage measuring and documentation portion of the assessment was conducted on the first day of the field assessment (July 28, 2010). DAR biologists Paul Murakawa and Brett Schumacher utilized closed circuit rebreathers to methodically move through the impacted reef area while working as a team to measure and document all signs of damaged reef habitat. Damaged area measurements were based off of the standard size of the Z-modules if they were single and laying flat ($2.952m^2$). In situations where several modules were stacked on top of each other, the base module was used with any additional impact area also measured and added to the base value. In some situations, broken pieces of concrete had scattered over the reef. These areas were also assessed, and all the measured reef damage added together. This assessment covered reef areas with depths ranging from 40' to 80'. The results of this assessment are summarized in Table 1.

Undamaged Coral Reef Habitat Assessment

In addition to the measurements of the total impacted reef area, it was necessary to fully characterize the undamaged reefs surrounding the impacted sites. Transect assessments were designed to fully characterize the reef habitat by collecting a permanent photographic record of the benthos, measuring the total percent cover of living coral, measuring the structural complexity with rugosity, and by quantifying and documenting the total number, size, morphology and species of all coral colonies within the ten square meters of each transect.

To maintain consistency with methods used during past coral damage assessment cases, DAR biologists employed a 10 meter by 1 meter coral assessment transect. This assessment was conducted by a two-person dive team, which began the survey by deploying a 10m transect tape along the reef. One diver would then take a series of benthic photographs at half meter intervals along the transect tape. Photos were taken with the camera held perpendicular to and exactly 50 cm above the substrate. These photos were later analyzed with Photogrid software to allow for the total percent of living benthic coral cover to be calculated. While the first diver was taking photos the second diver measured reef rugosity by carefully laying a small brass chain along the reef to measure the total distance along the reef contour in relation to the straight ten meter transect tape. The divers then surveyed the coral community within ½ meter of the 10m long transect tape. Each member of the dive team was responsible for surveying the corals on one side of the transect tape. This survey included counting each coral colony and characterizing it according to taxonomy, growth form, and size. A standardized archeological black and white half-meter stick was used for reference during size measurements.

A total of 15 of these assessment transects were conducted on undamaged coral reef that was adjacent to the impacted areas. This level of assessment is consistent with past coral damage cases on Maui, where DAR biologists used from 2 to 6 control reef characterization transects per coral damaged area. In the present case, assessment transect placements were determined by the proximity to the impacted reef and were designed to adequately represent the various types of damaged coral reef habitats (Figure 2). Two dive teams conducted these assessment transects. Russell Sparks and Kristy Stone conducted two days of assessment dives (July 28 & 29, 2010) and completed a total of 9 transects within the main reef (40' depth-transects 1-5) and the finger reef (60' depth- transects 6-9). The technical dive team of Paul Murakawa and Brett Schumacher utilized closed circuit rebreathers to conduct 4 hours of assessment work on July 29, 2010. Their assessment efforts concentrated on the deeper reefs. Areas they worked in included the patch reef (60-70' depth - transects 10-11) and the edge reef (80' depth – transects 12 - 15) (Figure 2).

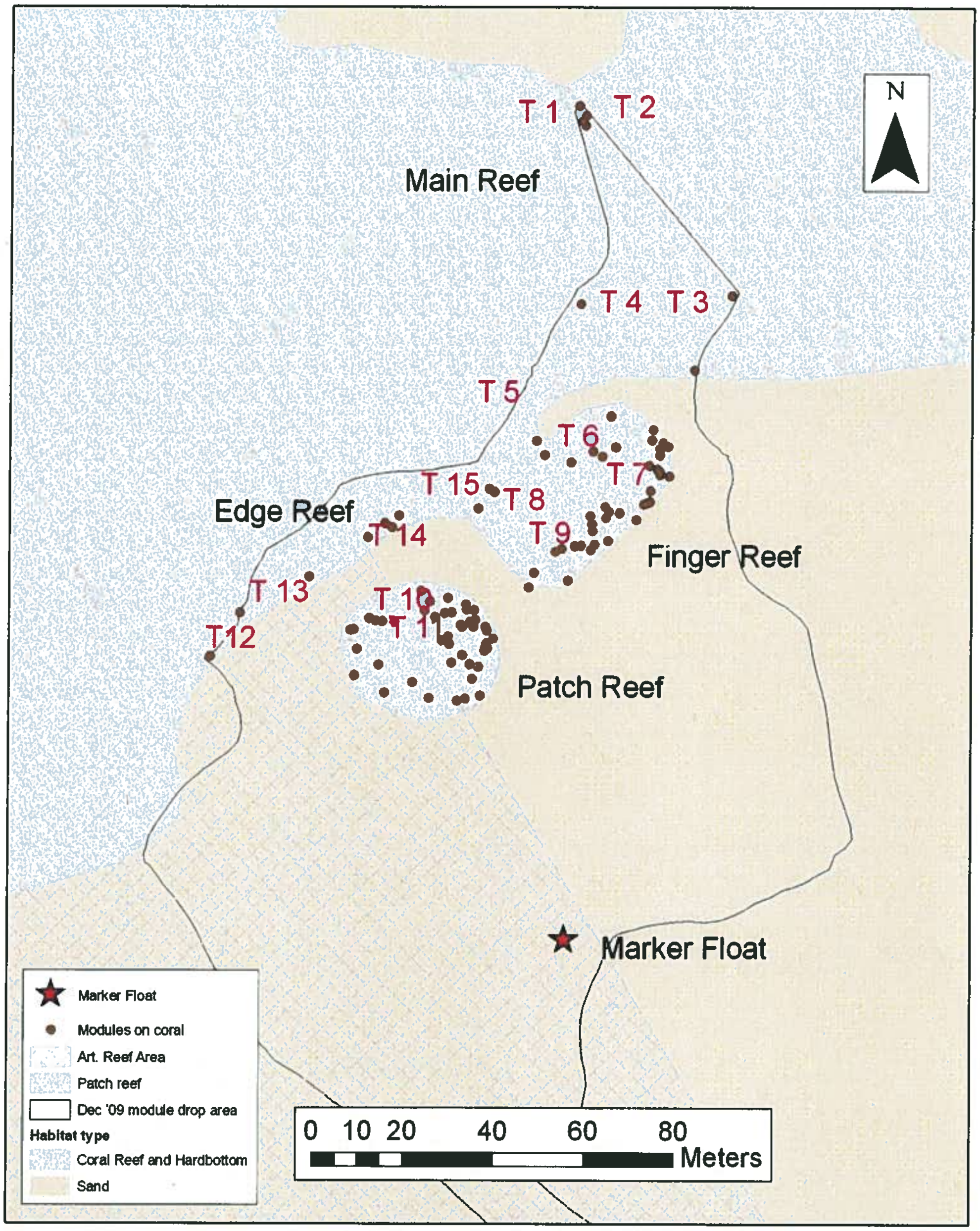


Figure 2: Map of the impacted reef area, with grey grid representing the designated artificial reef area, tan area representing sand, and the blue area representing coral reef habitat. Small dots are each of the 125 Z-modules currently sitting on reef habitat, red numbers represent the 15 reef assessment transects that were conducted on July 28 & 29, 2010, and the red star shows the marked final deployment site.

Assessment Results

Table 1 shows the results of the damaged coral reef area assessment with the total reef area damaged calculated at 311.79 m^2. The majority (84%) of damage occurred on the patch and finger reefs (Figure 2 & Table 1).

Table 1: Results of the damaged area assessment in relation to specific reef areas where the Z-module deployment resulted in habitat damage.

Reef Location	Damaged Coral Area Square Meters (m^2)
Patch Reef	138.007m^2
Main Reef	28.847m^2
Finger Reef	122.446m^2
Edge Reef	22.488m^2
Total Damaged Reef Area	**311.79m^2**

Overall, the assessment results suggest that the impacted coral reef habitat should be classified as having a medium coral ecosystem value. This reef classification is made based on coral complexity, vertical reef structure, and the percent of living coral cover. Based on detailed analysis of digital benthic photoquadrats, the average live coral percent cover value was determined to be 48%. This is a typical value for a deepwater monotypic finger coral (*Porites compressa*) reef. Along the leeward coast of Maui, in water deeper than 40', the lack of regular wave energy allows these finger coral reefs to grow fairly high with individual finger projections increasing in distance from one another. In this way the reef creates "dead" spaces between each coral finger. Some of these dead spaces fill in with small coral recruits or other crustose coral species, eg. rice coral, (*Montipora spp*.) and corrugated coral, (*Pavona varians*). However, much of these dead spaces fill in with either turf or coralline algae (Figures 3 & 4).

The impacted reef habitat did have fairly high vertical structure with an average rugosity measurement of 1.68. This value is consistent with a high coral value reef, but in this case, the structure was not composed of large crevices, cracks and mounds of coral. Instead the value was high because of the many small vertical peaks from the finger coral itself which offer limited shelter for most fish species. Most importantly, however, is the fact that critical large lobe and branching coral species were nearly non-existent. Large corals classified as having high ecological service value (lobe and branching coral colonies >80cm) accounted for only 1% of all the coral colonies surveyed. Medium ecological service value corals (lobe and branching corals 20 – 80cm, and finger corals >20cm) accounted for 22% of the reef, while the majority of the corals observed (77%) were classified as having low ecological service value (encrusting coral species and all other corals <20cm in size). Corals of this type provide little vertical structure and therefore provide a lower value habitat for other reef animals. This classification of medium reef ecosystem value, does not, however mean there are not any valuable ecosystem services provided by this type of reef habitat. For example, deeper water finger coral reefs of this type provide an important nursery habitat for many juvenile surgeonfish, as well as adult fish habitat for several smaller reef fish species (angelfishes, butterflyfishes, etc).

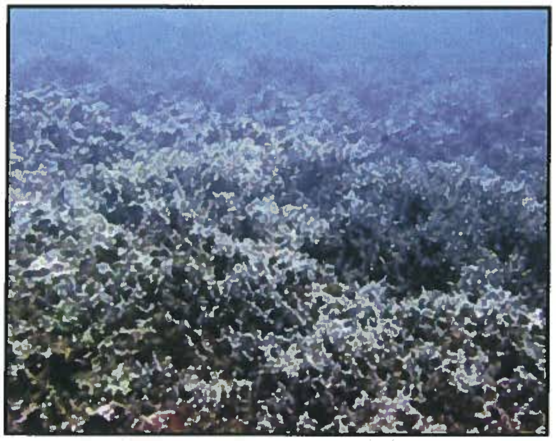


Figure 3: wide angle view of the Keawakapu finger coral reef.

Figure 4: Close up look at the dead spaces filled with small crustose corals, turf and coralline algae.

The total number of coral colonies impacted by the December 2, 2009 Z-module deployment was estimated based on the results of the undisturbed reef assessment transects. Table 2 outlines the results of the coral colony counts for each of the fifteen 10m x 1m transects. The average number of coral colonies per transect was calculated at 170. A one-tailed 90% confidence interval was calculated on the total coral numbers, and then independently on each of the three coral ecological value groups (high, medium, and low). This method of estimating coral damage accounts for natural variability and is conservative in favor of the responsible party. In addition it is the standard approach used by DAR when investigating coral damage cases where the actual number of damaged corals cannot be directly documented. Based on the 90% confidence level, and by calculating the number of coral colonies per unit area (m^2), we were able to estimate the total number of impacted coral colonies at approximately 4,914. The analysis of the individual coral ecological group categories resulted in estimated damages of around 31 high value corals, 1,077 medium value corals, and 3,740 low value (Table 2).

Table 2: Results of the 15 coral colony assessment transects. Corals are grouped in ecological value classification (High, Medium, Low). Variability between transects is accounted for with a one-tailed 90% confidence interval. Coral Density is calculated by dividing the estimated corals per transect (90% lower confidence limit) by the area of each transect (10 m^2). The estimated total coral damaged and the estimated coral damaged within each ecological value group is shown highlighted in yellow.

Transect	High Value Coral		Medium Value Coral			Low Value Coral		Total	Rugostiy	% Coral
Number	Lobe	Branching	Lobe	Branching	Finger	Crustose	<20cm	Corals		Cover
T-1	1	0	18	2	26	197	42	286	1.80	57.40
T-2	7	0	19	0	21	119	8	174	1.69	54.40
T-3	3	0	11	3	23	107	2	149	1.82	53.80
T-4	3	0	19	2	30	137	21	212	1.59	52.00
T-5	0	0	12	0	31	116	10	169	2.00	42.20
T-6	0	0	8	0	22	110	4	144	1.67	56.80
T-7	1	0	15	1	24	128	11	180	1.82	51.60
T-8	0	0	13	1	28	116	7	165	1.66	51.20
T-9	2	0	18	2	29	102	6	159	1.82	52.40
T-10	2	0	21	0	14	98	28	163	1.56	30.80
T-11	1	0	25	0	20	106	20	172	1.47	27.20
T-12	0	0	6	0	23	115	8	152	1.64	44.80
T-13	2	0	9	0	23	94	17	145	1.44	51.20
T-14	0	0	3	0	19	132	7	161	1.63	47.60
T-15	2	0	9	0	13	93	4	121	1.54	48.00
Mean Coral Colonies	1.60		37.53			131.00		170.13	1.68	48.09
Standard Deviation	1.84		9.07			33.38		37.88		
90% Lower Confidence Limit	0.99		34.53			119.96		157.60		
Density (Corals/m^2)	0.10		3.45			12.00		15.76		
Total Impacted Area (m^2)	311.79	(Table 1)								
Total Damaged coral	30.87		1076.61			3740.23		4913.83		
	Total High Value Coral = 31		Total Medium Value Coral = 1,077			Total Low Value Coral = 3,740		Total Damaged Coral = 4,914		